distinguished mineralogically from the latter by the presence of muscovite and a more sodic plagioclase and the absence of hornblende. Field evidence suggests that the irregular acid segregations were formed at the same time as the crystallization of the diorite, whereas the regular dykes of aplite, pegmatite and quartz are post-granite.

In the Parish of Purfleet a narrow mass of fine-grained basic rock ranging from diorite to uralite-dolerite borders the granite at its contact with slates. The dolerite-slate contact is not exposed, but xenoliths of dolerite are present in the granite, which has been modified by a little hornblende close to the dolerite contact. The xenoliths contain much interstitial quartz; the hornblende has been recrystallized into actinolitic aggregates and a little biotite is developed near the margins of the xenoliths.

Near "Melrose" a small area of dioritic and hornblende-rich rocks occurs amongst metamorphosed tuffs, lavas and sediments between the Wyangala bathylith and the Pine Mount intrusion. The diorites are of even grain-size with subhedral hornblende and andesine, epidote and anhedral quartz. Orange-brown biotite has been developed in amphibole in one rock, presumably due to contact metamorphic effects of the younger granite. The amphibole has distinct orientation and parallel veins of zoisite traverse the specimen.

The Wyangala Bathylith.

The greater part of the bathylith is composed of plutonic rocks which fall between granite and granodiorite in composition. In the area examined the only hornblende-bearing granitic rocks within the bathylith occur as xenoliths; the more melanocratic granites usually contain a greater proportion of biotite and plagioclase. The phases mapped are: porphyritic gneiss, slightly gneissic granite, massive biotite-granite, and acid marginal types.

(i) *Porphyritic Gneiss.*

This rock appears to be restricted to the northern part of the Wyangala bathylith, and, as far as is known, is not developed in any other bathyliths of the same type in New South Wales. It is not merely a marginal phase but occupies an area eight miles wide between Springvale and Reid's Flat, across which foliation is noticeable and moderately uniform. An elongated belt of pelitic country rocks which interrupts the porphyritic gneiss at Mt. Darling is linked with another belt at Alston, and this widens south along the Lachlan Valley, separating the Wyangala and Bigga sections of the bathylith.

The porphyritic gneiss is generally of medium to coarse grain-size with phenocrysts (porphyroblasts?) of white potash felspar up to 8 cm. in length; the groundmass minerals are bluish quartz, lustrous biotite and white felspars. The biotite flakes lie in parallel planes, producing a platy flow structure or foliation. In the strongly foliated rocks biotite forms irregular layers bent around discoidal masses of quartz and felspar, and tabular phenocrysts and xenoliths are arranged with their longest axes parallel to the dip of the foliation planes.

In thin sections quartz is seen to occur in anhedral grains with highly undulose extinction and, in the more gneissic types, in streaky layers and granular aggregates between more resistant felspars. Similar features have been noted in gneissic granites from Wyalong (Watt, 1899) and Adelong (Vallance, 1954), and have been ascribed to post-consolidation effects involving recrystallization and plastic flow.

The felspars are in tabular, slightly rounded crystals and grains, and although some are cracked and bent in the more foliated rocks, they have not been granulated to such an extent as the quartz. Potash felspar usually exceeds plagioclase; it is commonly microcline which shows characteristic twinning, especially in the smaller grains and adjacent to granulated areas. A perthitic intergrowth is often apparent, but the intergrown albite makes up only a small percentage of the felspar.

The phenocrysts (or porphyroblasts) are also of microcline perthite, of the type known as shadow perthite (cf. Plate 6 of Emmons et al., 1953). They enclose anhedral quartz and more euhedral plagioclase and biotite, which are the same as in the groundmass. These inclusions may be arranged in one or more zones parallel to the crystal margin and represent pauses in growth of the felspar; however, the phenocrysts are not mantled by sodic felspar, as in typical rapakivi granites.

Plagioclase forms subhedral, somewhat rounded crystals with sutured margins, and shows strain effects and some granulation. The composition varies from oligoclase in the normal rock to andesine in more melanocratic types, where it may exceed potash felspar in abundance.

Biotite tends to form large flakes in the less foliated rocks as a reduction in grain-size results from the movements which produced the foliation. Inclusions of rutile, apatite and zircon are common, and there is often alteration to chlorite and epidote. Muscovite is present only in the most acid gneisses, but sericite, as an alteration product, mottles the felspars, especially plagioclase.

A melanocratic gneiss at Bennett's Springs has oligoclase-andesine and microcline phenocrysts of varying size with abundant biotite in a mass of granular quartz and felspar. The excess biotite and the muscovite in this rock have been derived from mica-rich xenoliths of sedimentary origin, which are found in all stages of disintegration.

(ii) *Slightly Gneissic Granite.*

These rocks differ from the porphyritic gneiss in that they show less pronounced foliation and lack felspar phenocrysts. They outcrop on the northern side of the bathylith between Reid's Flat and Garland, and are found in apophyses between Frogmore and Taylor's Flat; other smaller occurrences are near Newham's Creek, surrounded by porphyritic gneiss, and south-west of Darby's Falls, where they form a narrow zone between porphyritic gneiss and massive biotite granite. Faint foliation is also visible at the margin of the massive granites north-west of Darby's Falls, and at one locality a few scattered phenocrysts are developed.

(iii) *Massive Biotite-Granite.*

Massive granites form a western border to the porphyritic gneiss up to four miles wide and twenty miles long between Kenyu and the northern end of the bathylith, and are also found between Reid's Flat and Bigga. West of the confluence of the Lachlan and Boorowa Rivers there is a gradation over several hundred yards from porphyritic gneiss through slightly gneissic granite to massive granite. There is no evidence of one type of granite having intruded the other.

The minerals of the massive granites are little different from those of the more gneissic rocks. Quartz, which loses the bluish tint characteristic of the gneisses, shows very few strain effects other than undulose extinction. Potash-felspar is reduced in amount and plagioclase is more abundant. Except for the presence of microcline, the rocks are somewhat similar to the hornblende-free granodiorite of Cowra (Stevens, 1952*b*), and contain similar but less abundant pelitic xenoliths to the east of that town.

(iv) *Acid Granite, Aplite and Granite-Porphyry.*

First to be noted are the two-mica gneissic granites, which are usually found at the margin of the porphyritic gneiss. They are cream- or pink-coloured, with obvious muscovite as well as granulated quartz, oligoclase, microcline and a little biotite. The micas occur together in clots which are often elongated, giving a planar structure.

Aplitic and acid granites outcrop where the bathylith narrows at Kenyu and to the north, muscovite-bearing porphyritic granites are found along the boundary between porphyritic gneiss and massive granite. Near Kenyu, dykes and apophyses of quartz-felspar-porphyry, granite and granite-porphyry project from the main mass of granite. A dyke of medium-grained, deuterically-altered granite runs parallel to the main contact and appears to have been responsible for the introduction of gold and copper near Godfrey's Creek, while acid gneissic granites occur close to the copper-bearing tungsten deposits at Frogmore and Reid's Flat.

Aplites are not as common as the coarser acid granites, but a number of dykes and veins has been noted, especially in well-exposed areas close to the bathylith margin (e.g. Wyangala Dam spillway). Aplite and pegmatite dykes appear at the northern extremity of the porphyritic gneiss between Milburn Creek and Mt. McDonald, and around the dioritic mass at Cocomingla. The pegmatites often show graphic fabric and may contain muscovite or tourmaline as accessories. North of Reid's Flat a greisen with pink andalusite borders the gneissic granite, and is intersected by quartz veins containing wolframite.

(v) *Xenoliths.*

Xenoliths in the gneissic granites are mostly dark and fine-grained, with a biotite-felspar-quartz assemblage. Small porphyroblasts of white felspar and blue-grey quartz are common, and near Reid's Flat the former reach a size comparable with those in the gneiss itself.

In xenoliths found in coarse, slightly gneissic granite in the Newham's Creek area the fine-grained parts are composed of biotite flakes with distinct orientation, which wrap around tabular andesine and quartz grains. Some plagioclase porphyroblasts are composite with traces of oscillatory zoning, especially near the margins.

Intergranular quartz is developed in xenoliths enclosed in more gneissic granite and zones of granulation in the host rock split in the xenolith, which has been more resistant to deforming forces than the granite. Biotite is concentrated at the margins of such xenoliths, especially on the sides "sheltered" from shearing stress. Porphyroblasts are of microcline-perthite, oligoclase (with ill-defined twinning) and quartz (in irregular masses showing undulose extinction). Microcline, which encloses minerals of the matrix and optically oriented areas of quartz, is associated with plagioclase and surrounded by a quartz-albite (myrmekitic) border.

On Wyangala Dam spillway dark lenticular xenoliths contain porphyroblasts of microcline identical with those present in the gneiss. Another type of xenolith from Reid's Flat with large microcline porphyroblasts differs in that ferromagnesian minerals are almost absent in the groundmass. The latter is composed of irregular areas of strained and granulated quartz and equant crushed grains of microcline. In general, the more strongly foliated the granite, the more lenticular and oriented the xenoliths become.

Gneissic hornblende-bearing xenoliths occur in porphyritic gneiss in a road cutting south of Darby's Falls. Notable features are the oligoclase-andesine porphyroblasts and clots of biotite, hornblende and sphene; biotite is developing from hornblende by reaction with the more acid magma. Hornblende and sphene are uncommon in the gneisses and their presence links these xenoliths with the earlier diorites.

On the north-western side of the bathylith the massive granites contain unoriented xenoliths of a schistose appearance, with biotite, andesine and interstitial quartz and (?) cordierite. Similar pelitic xenoliths, sometimes containing spinel, almandine or sillimanite, have been found in the Cowra Granodiorite (Stevens, 1952*b*).

(vi) *Basic Dykes.*

Basic dykes intersect the gneissic granites near Wyangala Dam and Taylor's Flat. They are generally less than four feet wide and their directions are controlled by jointing in the granite.

The dyke-rocks are fine-grained dolerites with occasional andesine phenocrysts in a groundmass of felspar, epidote and chlorite.

(vii) *Structure in the Wyangala Bathylith.*

The most notable structural feature of the bathylith is the dominant north-south strike of the foliation and platy flow structure. There is some deviation from this direction only at the northern end of the bathylith between Milburn Creek and Mt. McDonald and south of Garland. In the former area the strike of the foliation is sub-parallel to the margins (which converge northwards) and in the latter it follows a N.E.–S.W. ridge of porphyritic gneiss.

In most places the foliation planes dip steeply to the west, though the dip is difficult to determine with certainty except with stable, well-exposed outcrops. The best exposures are at Wyangala Dam, where the porphyritic gneiss shows strongest foliation, dipping west at 65° to 70°. A linear parallelism of phenocrysts makes this a combined structure of planar and linear elements.

Zones of intense mylonitization parallel the foliation planes, producing compact, finely-banded rocks which superficially resemble slate beds, ranging from a mere film up to 50 feet or more in thickness. Secondary zones of crushing and fracture dip west at a shallower angle and acid veins in gneissic granites north of the dam follow the same two directions. Similar acid veins traverse both the gneiss and the later aplite dykes on the spillway.

The mylonitic rocks consist of layers of sericite and chlorite alternating with layers of granular quartz and felspar with larger, shattered microcline grains. The high degree of compaction of the rocks is due to impregnation by siliceous solutions which produced the acid veins in the gneiss and aplite.

Strongly foliated gneisses occur in two main zones east and west of Mt. Darling, converging northwards towards Mt. McDonald. Both are along gneiss-slate contacts for some part of their length and the foliation in the gneiss of the western zone is continuous with the zone of strong cleavage in the country rocks north of Mt. McDonald.

The stronger foliation of the gneisses is in part primary, and there is evidence that movements continued in the same zones after consolidation of the gneiss and intrusion of the aplites.

The Pine Mount Granodiorite.

East of Cowra and north-west of Wyangala Dam, granodiorite grading into hornblende-biotite-granite and quartz-mica-diorite, with associated aplites and acid phases, has invaded andesites, tuffs and slates of Ordovician age. Granodiorite is the main rock type, and the intrusion (a small bathylith or stock) is named after the most prominent hill in the area.

The intrusion is roughly elliptical, elongated east-west with a south-easterly prolongation to "Melrose", where it adjoins porphyritic gneiss of the Wyangala bathylith. The two bathyliths approach one another closely, being separated by only a few feet of phyllite at one point, but the actual contact is not exposed. Along the southern boundary the Pine Mount intrusion is separated from the Wyangala bathylith by a belt of metamorphosed tuffs about one mile wide, and for some distance the margins of the intrusions curve sympathetically. Apart from contacts with later dykes, no sharp contacts are visible within the intrusion, and changes in composition in the granitic rocks are gradual.

Hornblende-biotite-granite makes up the western part of the intrusion, with a fine-grained type in the north-west. The former grades into granodiorite as Pine Mount is approached, and this rock continues east and south with some coarser varieties south-east of Pine Mount. Quartz-mica-diorite makes up an apophysis in the north-east and related types are found near Milburn Creek in dykes invading the tuffs. Dykes of aplite are common near the margin of the intrusion, but pegmatite is rare.

Xenoliths are notable along the eastern margin of the intrusion, and good exposures of the sharp contact may be seen in Milburn Creek, where several small hornfelsed roof pendants are preserved. Away from effects of the Wyangala bathylith, thermal metamorphism has not extended far from the margin of the Pine Mount intrusion.

The granites and granodiorites of the northern part of the intrusion differ from those of the Wyangala bathylith in the following respects: (1) the constituent minerals show no strain effects; (2) the potash felspar is orthoclase, usually heavily kaolinized; (3) plagioclase greatly exceeds orthoclase; and (4) hornblende is present.

However, in the south-east prolongation of the intrusion, granodiorite from a prominent hill west of "Melrose" shows signs of stress in thin sections, although there is no apparent lineation in outcrops. Microcline is present, and quartz exhibits undulose extinction and slight granulation at grain boundaries.

Orientation of minerals becomes stronger as the boundary of the porphyritic gneiss is approached. It is likely that these structures are secondary, having been impressed on the Pine Mount intrusion after consolidation. The maximum effect is concentrated at the boundary between the two bathyliths, where schistose rocks have been produced.

The hornblende-bearing granites and granodiorites which adjoin the Wyangala bathylith in the upper part of Milburn Creek are similar to those of the Pine Mount intrusion. Unfortunately, field relations between these rocks and the neighbouring slightly gneissic granites are not clear.

At the northern end of this intrusion near Lucan, there is a great variety of fine-grained granites, aplites and granophyres with some quartz-felspar-porphyries and hornblende-porphyrites. Many of the rocks appear to be hybrids between granodiorite and more acid phases and it is impossible to map them separately. The same diversity of rock types is found at the head of Waugoola Creek, but in the narrow section of the intrusion south of Milburn Creek only medium-grained granodiorite is present.

Most of the rocks from this eastern equivalent of the Pine Mount Granodiorite have a very faint parallel orientation of ferromagnesian minerals and sub-parallel fracturing of quartz grains. The fracture planes are close to vertical and trend north-south, but the orientation of the ferromagnesian minerals has not been investigated.

The massive, hornblende-bearing, granitic rocks are quite different from the biotite-rich and frequently gneissic rocks of the Wyangala bathylith, and from a consideration of structural features it is likely that the Pine Mount intrusion is the younger.

Chemical Data.

Five granitic rocks from this area have been analysed—three from the Wyangala bathylith and two from the Pine Mount intrusion. Analyses of these are given in Table 1 together with the Cowra Granodiorite and granites from the Murrumbidgee, Kosciusko and Adelong bathyliths.

The analysed "granites" of the Wyangala bathylith have SiO_2 percentages ranging from 66 to 76; but the most acid variety (which is comparable with the "white gneiss" of the Murrumbidgee bathylith) is exceptional, and the average SiO_2 percentage for the whole bathylith would be less than 70. CaO is variable but generally rather high (especially in the porphyritic gneiss), and potash exceeds soda in Wyangala bathylith rocks and those of comparable intrusions. The granodiorites from Cowra and the Pine Mount intrusion have a higher soda : potash ratio. Of these, the hornblende-biotite-granite from Rocky Peak (near the south-east margin of the Pine Mount intrusion) is closest to the typical rock of the Wyangala bathylith in chemical composition.

Table 1.

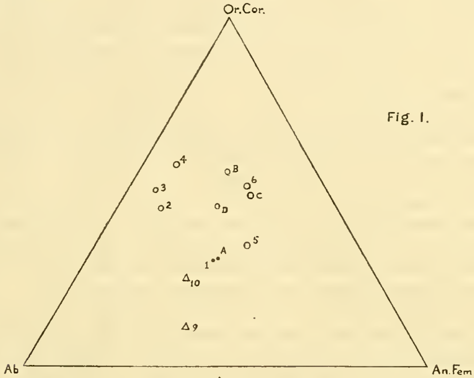
Chemical Analyses of Granitic Rocks of the Wyangala and Related Bathyliths and of the Cowra and Pine Mount Intrusions.

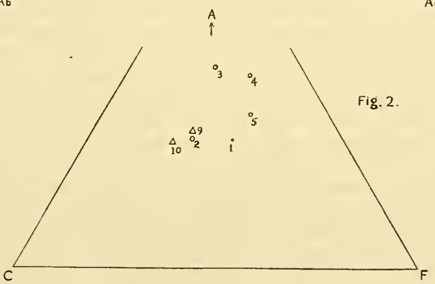
—	1	2	3	4	5	6	7	8	9	10
SiO_2	67·64	66·71	72·03	76·08	68·93	70·31	67·67	74·99	65·75	72·30
Al_2O_3	14·54	15·52	16·29	12·93	15·80	18·68	16·02	10·44	16·63	14·50
Fe_2O_3	2·24	0·63	0·39	0·70	0·69	0·63	0·56	n.d.	1·41	0·73
FeO	4·05	3·74	1·73	0·90	3·75	1·83	3·79	5·58	3·29	1·98
MgO	1·13	0·76	0·40	0·53	1·94	1·10	2·20	0·09	0·90	0·52
CaO	2·70	3·83	1·61	0·52	2·50	2·22	2·12	0·50	4·08	2·60
Na_2O	3·04	2·86	2·65	2·31	1·88	1·37	2·86	2·66	4·90	3·63
K_2O	3·12	3·58	3·52	5·26	2·37	3·32	3·41	4·82	1·30	2·53
H_2O+	0·93	0·56	0·73	0·33	0·65	0·65	0·57	0·52	0·59	0·62
H_2O-	0·23	0·14	0·12	0·19	0·10	0·09	0·18	0·17	0·19	0·13
TiO_2	0·94	1·25	0·32	0·35	0·90	0·35	0·71	tr.	1·23	0·36
P_2O_5	0·12	n.d.	n.d.	0·12	n.d.	0·06	—	—	n.d.	n.d.
MnO	0·04	0·05	0·03	0·06	0·09	—	0·03	tr.	0·20	0·19
	100·72	99·63	99·82	100·28	99·60	100·61	100·12	99·77	100·47	100·09

1, Cowra Granodiorite, 4½ miles N. of Cowra.—2, Porphyritic gneiss, Darby's Falls. Anal. J. Pyle.—3, Coarse, slightly gneissic granite, Newham's Creek.—4, Gneissic granite, Wyangala Dam. Anal. W. A. Greig. *Dept. Mines N.S.W. Ann. Rept.* for 1932, p. 96.—5, Gneissic granodiorite, Charlotte Pass, Mt. Kosciusko.—6, Coarse biotite-granite. A phase of the "Blue Gneiss" (Murrumbidgee bathylith). Shannon's Flat, W.N.W. of Cooma. Anal. G. A. Joplin. Quoted by T. G. Vallance, Proc. Linn. Soc. N.S.W., 78 (1953): 210.—7, Granodiorite, portion 62, par. Wallace, Co. Wynyard. Anal. T. G. Vallance, *ibid.*—8, White gneiss, Bunyan. Anal. G. A. Joplin, *ibid.*, 68 (1943): 172.—9, Fine-grained granodiorite, E. of Holmwood (near Cowra).—10, Hornblende-biotite-granite, Rocky Peak, S. of Pine Mount.

Analyses 2, 3 and 4 are of rocks from the Wyangala bathylith; 9 and 10 from the Pine Mount intrusion. Analyses 1, 3–5, 9 and 10 by N. C. Stevens.

On an Or. Cor. : Ab : An. Fem. diagram (Text-fig. 1) the three analysed representatives of the Wyangala bathylith are relatively acid, falling near the Or. Cor. : Ab edge. The gneissic granodiorite from Kosciusko and several others from the Murrumbidgee bathylith and north-east Victoria are more centrally situated and thus more basic. The Cowra Granodiorite and related rocks fall close to this field, but the granodiorites of the Pine Mount intrusion do not. Dissimilarities are not so well shown in the AFC diagram (Text-fig. 2) because of the relatively high CaO in the porphyritic gneiss. As lime-bearing ferromagnesian minerals are absent in the rock, the lime must be contained in plagioclase.





Text-fig. 1.—Or. Cor : Ab : An. Fem diagram for granitic rocks of the Wyangala and related bathyliths and of the Cowra and Pine Mount intrusions. 1-6, 9 and 10 as in Table 1.

A, Canowindra Porphyry, 6 miles E. of Canowindra. Stevens, Proc. Linn. Soc. N.S.W., 77 (1952) : 134.

B, Quartz-mica-diorite (hornblende-free), Cooma. Anal. G. A. Joplin. *Ibid.*, 68 (1943) : 171.

C, Quartz-diorite, Cooma. Anal. E. A. Burnard and E. T. Wallace. Quoted by Joplin, *ibid.*, 68 : 171.

D, Granite, Koetong mass, V. Anal. C. M. Tattam, *Bull. Geol. Surv. Vict.*, 52 (1939) : 38.

O = gneissic granites; ● = Cowra Granodiorite and the related Canowindra Porphyry; △ = Pine Mount intrusion.

Text-fig. 2.—AFC diagram for granitic rocks of the Wyangala and related bathyliths and of the Cowra and Pine Mount intrusions. 1-5, 9 and 10 as in Table 1.

O = gneissic granites; ● = Cowra Granodiorite and the related Canowindra Porphyry; △ = Pine Mount intrusion.

Origin and Age of the Plutonic Rocks.

In this part of New South Wales the major intrusions of granitic rocks are found to the south of Cowra and Woodstock, while to the north of these towns the intrusions are mostly of minor importance (excluding the sill-like Cowra Granodiorite and Canowindra Porphyry).

In discussing the mode of emplacement of the granites, we must consider whether there was intrusion of magma with displacement and assimilation of the country rock or whether the granites were formed *in situ* by transformation of the sedimentary rocks with or without the aid of emanations.

To express an opinion on which of these processes obtained, the nature of the granite contacts and the degree of metamorphism of the metasediments must be examined critically. In every place where the granite-sediment contact is exposed, the boundaries are sharp, with no transitional zone of felspathized rocks, migmatites or extensive metamorphic zones. In some places the pelites are scarcely altered a few yards from the contact. It is true that, in other places (e.g. Old Woman Creek) there seems to be an intimate mixture of granite and sediment, but the contact, like that of Sea Point, S. Africa (Reed, 1951), "is a moved one, showing mechanical mixing of softened-up slate and viscous granite". The geological setting is not in keeping with large-scale granitization *in situ*.

Certain features of the porphyritic gneiss, such as the porphyroblasts in the xenoliths and the identical felspars in the gneiss, suggest an origin by granitization; but there are no porphyroblasts developed in the country rocks at the granite margins. From a detailed study of xenoliths in the Cowra intrusion (Stevens, 1952*b*) it is suggested that the xenoliths in the porphyritic gneiss are of sedimentary origin. If so, the grade of metamorphism is much higher and of a different type from that found at the exposed contacts. The evidence suggests that the porphyritic gneiss has not been generated *in situ*, but has moved into its present position from a much deeper level, where it was most likely produced by granitization of sediments.

"Termier maintained that if a granite is surrounded by a narrow aureole it is certain that the granite has come from somewhere else, ready-made; if it is surrounded by a vast metamorphic aureole it has been formed in place while the neighbouring rocks were regionally metamorphosed" (Reed, 1948). In eastern New South Wales granites surrounded by extensive metamorphic zones have been described by Joplin (1942, 1947) and Vallance (1953, 1954). Both authors postulate a magma to have been present, and Vallance (1954) cites chemical evidence to suggest that even these granitic masses were introduced into their present position rather than formed *in situ*. They have been termed synchronous bathyliths (Browne, 1931), injected during the main compressional movement, whereas later, higher-level plutons are called subsequent; Joplin (1948) has termed the intermediate type (of which the Wyangala bathylith is an example) "quasi-synchronous". These bathyliths are generally concordant with the country rocks and are marked by a gneissic foliation which may be strongest close to the margin (Den Tex, 1954) or have irregular distribution (Vallance, 1954).

In the case of the Wyangala bathylith the foliation is strongest close to the centrally-situated slate belts south of Wyangala, but granites at the north-eastern margin of the bathylith are only faintly gneissic and those at the western margin are quite massive. Granites of the apophyses and those close to east-west contacts are also less gneissic than rocks well within the bathylith. The marginal slightly gneissic and massive phases may be explained as successively later intrusions, injected after the main compressional forces had waned, a theory which is supported on the western side of the bathylith by acid and porphyritic marginal phases along the boundary of massive granite and porphyritic gneiss. However, east of Frogmore there is a progression from porphyritic gneiss through slightly gneissic granite to massive granite at the southern end of an apophysis, and there is little likelihood of separate intrusions.

The north-south foliation seems to have been produced by compressional forces from the west, the magma having been squeezed up westerly-dipping cleavage planes produced earlier in the country rocks by forces from the same direction. At either end of the bathylith where irregular east-west contacts caused turbulence in the magma there was less tendency for the rocks to become foliated. In U.S.A. the Boulder bathylith (Graut and Balk, 1934) shows somewhat similar structures with hornblende crystals forming lines pitching in constant directions at contacts. It is thought to have risen from considerable depths.

In contrast to the other granitic intrusions, the Pine Mount Granodiorite has its greatest length east-west, so that in general it cuts across the strike of the country rocks and emplacement seems to have been controlled by east-west joints. As it closely adjoins the gneissic granites it is unlikely that it represents a higher level of intrusion, unless large-scale uplift followed by a long period of erosion is postulated. It is suggested, therefore, that the granodiorite was intruded during a static period after the consolidation of the Wyangala bathylith, the magma having been basified slightly by hybridism with earlier basic rocks or by assimilation of andesites. The hornblende-bearing granodiorite east of the Woodstock–Wyangala road has been formed from the same magma and has consolidated under conditions of weak compression. These rocks merge into slightly gneissic granites of the Wyangala bathylith, and bear a closer relation to them than does the Pine Mount intrusion.

The origin of the pre-granite diorite and amphibolite will be fully discussed in a later paper; at this stage it may be noted that the association of similar basic rocks with gneissic granites at a number of places in south-eastern New South Wales indicates that the acid and basic rocks are genetically related. There is, however, no evidence that the basic rocks have been derived from sediments as a by-product of large-scale granitization.

The Wyangala gneissic granites invade strata as young as Silurian, but at no place are they in contact with Devonian or Late Palaeozoic rocks, so that their age cannot be determined accurately from field evidence. No granitic intrusions have been found in the large areas of Upper Devonian rocks between Orange and Boorowa, and it is quite possible that all the granites in this region are pre-Upper Devonian, associated with the Bowning or Tabberabberan orogenies.

There are strong lithological similarities between the gneissic granites of Wyangala and those of the Murrumbidgee bathylith. The supposed late Silurian age of the latter (Browne, 1929) depends partly on lithological similarities with pre-Middle Devonian granitic rocks of North Gippsland and partly on dissimilarities between gneissic granites and massive granites presumed to be associated with Tabberabberan and Kanimblan orogenies.

Joplin (1948) admits that gneissic and massive granites may be formed at the same level during different phases of the same orogenic epoch, and in the Wyangala bathylith gneissic and massive types are found side by side and even grade into one another with no sign of intrusive relations between them.

Upper Devonian strata rest on the massive Windermere Granodiorite at Murringo North, and on the northern extremity of the Young bathylith at Broula. The Windermere Granodiorite is intrusive into the Illunie Rhyolite, which may perhaps be correlated with the Bulls' Camp Rhyolite near Orange (Stevens and Packham, 1953). These rhyolites are thought to be Lower Devonian, but there does not seem to be any unconformity between them and the underlying Silurian strata. The Bowning orogeny, if it affected these rocks, must have taken place after the extrusion of the rhyolites and probably before deposition of the Garra beds. In the region under consideration the unconformity representing the Bowning orogeny is very slight compared with the Tabberabberan unconformity and there is no reason why the pre-Upper Devonian granites should not have been injected during the Tabberabberan orogeny.

Acknowledgements.

The writer wishes to thank Professor C. E. Marshall, Dr. W. R. Browne and Dr. G. D. Osborne for helpful suggestions during the course of the work; also those who have accompanied him to the area. The writer has benefited from discussions with the late Dr. Rutledge and with Mr. S. M. Hasan, who is working on the southern part of the same bathylith. One of the chemical analyses was carried out by Mr. J. Pyle, of the N.S.W. Geological Survey Chemical Laboratory, with the permission of the Chief Analyst, Mr. E. Reidy.

Some of the work was done while the writer was a Linnean Macleay Fellow, and financial assistance was also supplied by a Commonwealth Research Grant during the early part of the work.

References.

BROWNE, W. R., 1929.—An outline of the history of igneous action in New South Wales till the close of the Palaeozoic Era. PROC. LINN. SOC. N.S.W., 54: xiii.

———, 1931.—Notes on bathyliths and some of their implications. *J. Roy. Soc. N.S.W.*, 65: 112.

———, 1950.—Metallogenic epochs and ore-regions in the Commonwealth of Australia. *Ibid.*, 83: 96.

DEER, W. A., 1950.—The diorites and associated rocks of the Glen Tilt Complex, Perthshire. *Geol. Mag.*, 87: 181.

DEN TEX, E., 1954.—Stereographic distinction of linear and planar structures from apparent lineations in random exposure planes. *J. Geol. Soc. Aust.*, 1: 55.

EMMONS, R. C., et al., 1953.—Selected petrogenic relations of Plagioclase. *Geol. Soc. Amer.*, Mem. 52.

GROUT, F. F., and BALK, R., 1934.—Internal structures in the Boulder bathylith. *Ibid.*, Bull. 45: 877.

HARPER, L. F., 1919.—Tungsten deposits near Frogmore. *Dept. Mines N.S.W., Ann. Rept.* (1918): 159.

———, 1929.—Proposed dam on the Lachlan River at Wyangala. *Ibid.* (1928): 97.

JOPLIN, G. A., 1942.—Petrological studies in the Ordovician of New South Wales. I. The Cooma Complex. PROC. LINN. SOC. N.S.W., 67: 156.

———, 1947.—*Idem.* IV. The northern extension of the north-east Victorian metamorphic complex. *Ibid.*, 72: 87.

———, 1948.—On the question of interaction between primary granitic and primary basaltic magma under varying tectonic conditions. *Unpubl. D.Sc. thesis, University of Sydney.*

McLINTOCK, W. F. P., 1915.—On the zeolites and associated minerals from the Tertiary lavas around Ben More, Mull. *Phil. Trans. Roy. Soc. Edin.*, 55: 1.

MULHOLLAND, C. ST. J., 1950.—Phoenix wolfram mine, Frogmore. *Dept. Mines N.S.W. Geological Reports* (1939-1945): 68.

READ, H. H., 1948.—In symposium "Origin of Granite" (Gilluly, chairman). *Geol. Soc. Amer.*, Mem. 28.

———, 1951.—Metamorphism and Granitisation. *Geol. Soc. S. Africa, du Toit Memorial Lecture No. 2. Annexure to vol.* 54 of the *Transactions.*

REYNOLDS, D. L., 1949.—Observations concerning granite. *Geol. en Mijnbouw*, 8: 241.

STEVENS, N. C., 1951.—The geology of the Canowindra district, N.S.W. Part II. The Canowindra-Cowra-Woodstock area. *J. Roy. Soc. N.S.W.*, 84: 46.

———, 1952*a*.—Ordovician Stratigraphy at Cliefden Caves, near Mandurama, N.S.W. PROC. LINN. SOC. N.S.W., 77: 114.

———, 1952*b*.—Petrology of the Cowra Intrusion and associated xenoliths. *Ibid.*, 77: 132.

———, and PACKHAM, G. H., 1953.—Graptolite zones and associated stratigraphy at Four Mile Creek, S.W. of Orange, N.S.W. *J. Roy. Soc. N.S.W.*, 86: 94.

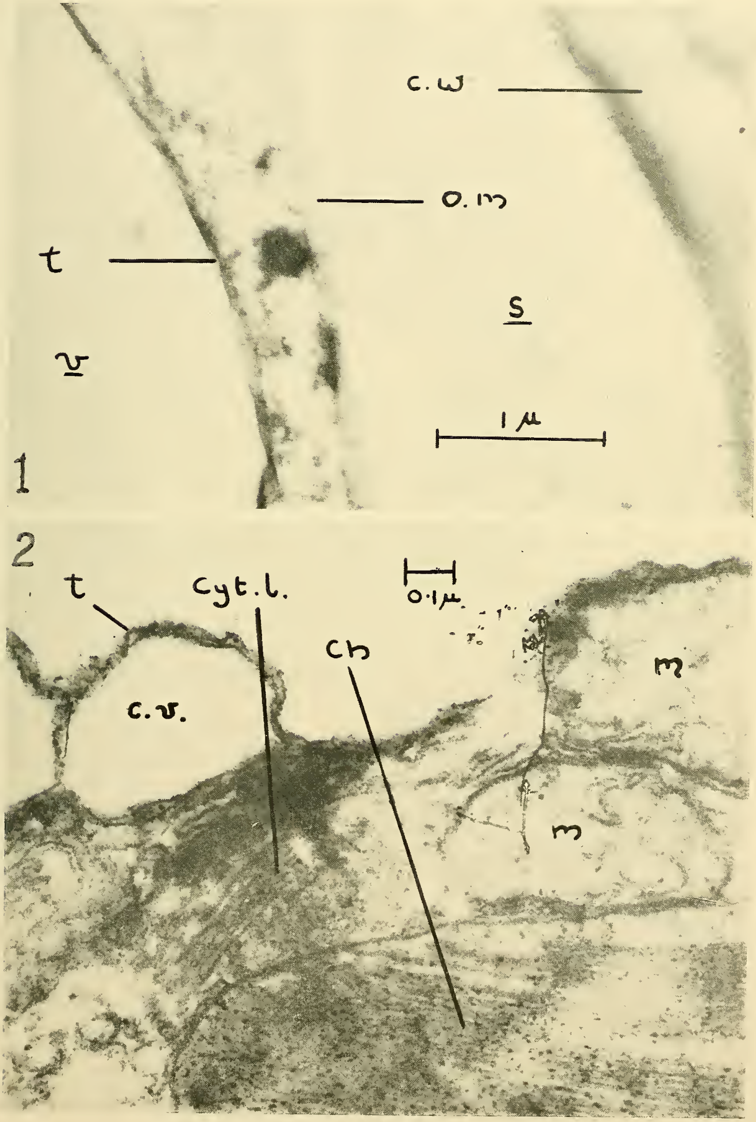
VALLANCE, T. G., 1953.—Studies in the metamorphic and plutonic geology of the Wantabadgery-Adelong-Tumbarumba district, N.S.W. Part I. Introduction and metamorphism of the sedimentary rocks. PROC. LINN. SOC. N.S.W., 78: 90.

———, 1954.—*Idem.* III. The granitic rocks. *Ibid.*, 78: 197.

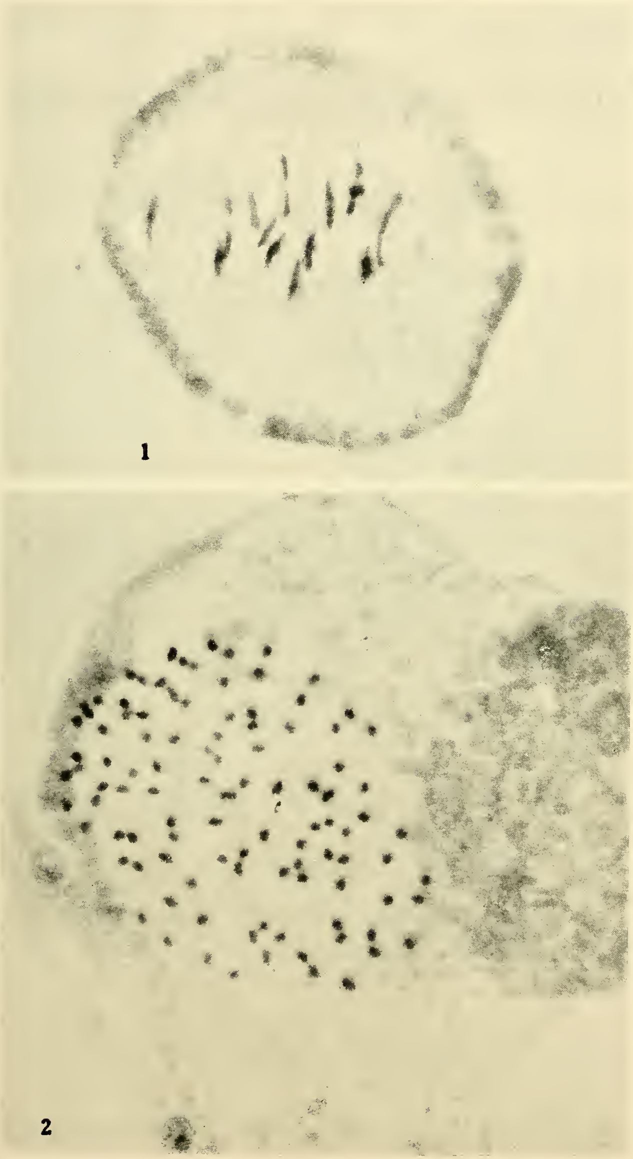
WATT, J. A., 1899.—Report on the Wyalong Goldfield. *Dept. Mines N.S.W., Min. Res.* No. 5

EXPLANATION OF PLATE IV.

Geological map of the northern part of the Wyangala Bathylith.



Electron micrographs of (1) Beetroot, (2) *Nitella* sp.



Drimys insipida. 1, Meiosis, microspore mother cell; 2, mitosis, tapetal cell.